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RESIDUAL TESTS OF DDT IN DIESEL OIL AS A FOLIAGE SPRAY TO CONTROL THE CALIFORNIA FLATHEADED BORER

(Melanophila californica Van Dyke)

by

Robert L. Lyon

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CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

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Division of Forest Insect Research

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SUMMARY

A small-scale test was made on the residual toxicity of DDT in diesel oil to the California flatheaded borer when applied to the foliage of ponderosa pine similating aerial application. Applications of 2 lbs. and 4 lbs. of DDT/acre were made to small ponderosa pine saplings and the resultant deposits were bio-assayed for residual toxicity one and five weeks later by confining a 50-member sample of adult flatheads into cages surrounding the treated foliage.

Both the 2 and 4 lb./acre treatments gave 100 percent kill after they had aged for one week. At five weeks of age, the 4 lb./acre deposit still provided very close to its maximum degree of protection but the 2 lb./acre deposit showed a very definite decline in toxic action.

It is believed, therefore, that a 2 lb./acre application can be expected to give adequate control in the field for a maximum of 2 to 3 weeks and would require three repeat applications in order to sustain a sufficiently toxic residue to control flatheads throughout their three-month emergence period. An application of 4 lbs. per acre may be expected to give satisfactory control with one repeat application. Each dose would involve a final deposit of 8 lbs. of DDT per acre.

INTRODUCTION

The California flatheaded borer (Melanophila californica Van Dyke) can periodically become very destructive to pine forests of California. The insect attacks ponderosa, Jeffrey, sugar, Coulter, Monterey, Digger and knobcone pines in Oregon, Washington, Idaho, California and Nevada.1/

1/ Keen, F. P. 1952. "Insect Enemies of Western Forests." U.S. Dept. Agr. Misc. Pub. 273, p. 170.

In watersheds and recreational lands of southern California the flathead is now causing heavy loss in Jeffrey pine stands. It is widespread in ponderosa and Jeffrey pine in California and is often found in forests located on exposed sites having shallow soil and deficient moisture.

The host tree may be killed outright by the singular attacks of flatheaded borers. The attack may be severe enough to kill the tree in one or two years or the tree may survive for several years under the repeated attacks of this insect.

The flatheaded borer and tree-killing bark beetles are frequently found together in the same dead or dying tree. It is believed that the flathead attacks first and predisposes the tree to attack by bark beetles. Thus it is probable that an outbreak of bark beetles can result from a build-up of flatheaded borers.

Past work on the California flatheaded borer has shown that the adult feeds on the foliage of its hosts. Nourishment derived from this foliage promotes sexual maturity in the adult since feeding is correlated with the development of sexual organs in both sexes and egg development in the female.2/ 3/ Because of this obligate feeding by the adult, the aerial application of a residual insecticide to the foliage of the insect's hosts shows promise as a control measure.

To test the potentialities of this approach to the control of flatheads, a small-size pilot study was carried on in the summer of 1955 at the Miami Field Base to determine the effectiveness of various doses of DDT in diesel oil when sprayed on small ponderosa pine in a fashion to similate aerial application. It was found that the equivalent of 2 lbs. DDT/acre was sufficient to kill 100 percent of the flathead adults after four days of confinement in cages surrounding the sprayed trees. This test was a measure of immediate toxicity since the introduction of test insects was made 5 to 7 hours after spraying. A test of residual-life was not made.

2/ West, A. S., Jr. 1947. "The California flatheaded borer (Melanophila californica Van Dyke) in ponderosa pine stands of northeastern California." Canadian Jour. Research, D. 25: 97-118.

3/ Lyon, R. L., Unpublished report - Tests with DDT in diesel oil as a foliage spray to control the California flatheaded borer (Melanophila californica Van Dyke). 1955. C.F.&R.E.S., Berkeley, California. 10 pp., illus. 12-5-55(mimeo.)

Since the flathead adults emerge over a period of approximately three months in southern California,[4/] a lethal deposit must be maintained on the foliage for that period of time if adequate control is to be obtained. In order to determine the probable residual life of DDT in diesel oil as a deposit on the foliage of ponderosa pine, a small test was carried out at the Miami Field Base during the summer months of 1956. The author was assisted by W. D. Bedard.

PROCEDURE

Plans as originally formulated called for testing the DDT deposits on foliage after they had been allowed to age for different lengths of time, up to two months. This would have involved the testing of 3 or 4 progressively older deposits. However, it soon became apparent that if test trees were sprayed July 1, in order to have two-month old deposits by the end of August, the test results would have been complicated by the inclusion of sprayed foliage that was not fully developed. When foliage is sprayed before the needles have developed to their full length the insecticide deposit will cover only that part of the needle that had developed up to the time of spraying. As the needles grow longer, there will be fresh needle surface completely void of an insecticide deposit. It would be difficult, therefore, to explain differences in kill from deposits of different age. For example, a reduction of kill from deposits of greater age could be imputed to deterioration in the toxic qualities of the deposit or to the formation of fresh needle surface devoid of the toxic agent.

Consideration of the influence of immature foliage on tests of residual toxicity is important for four reasons:

(1) The California flatheaded borer adults emerge in the field when the foliage of their hosts is immature.

(2) The caged adult feeds almost wholly on current foliage even when this foliage is immature. Flathead adults were reared from ponderosa pine and placed in a cage containing watered, ponderosa pine branches. The current foliage was approximately one-half grown. About 90 percent of the feeding took place on this immature foliage. Flatheads in the field would be expected to feed in the same way.

4/ Downing, G. L., Unpublished report - Emergence of Melanophila californica Van Dyke from infested Jeffrey pine - Mt. Laguna, California, May-August, 1954. C.F.& R.E.S., Berkeley, California. 6 pp., illus. 6-22-55 (mimeo.)

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(3) Feeding by caged adults takes place largely near the apex of the fascicle sheath. The same feeding pattern probably exists in field populations.

(4) That portion of the immature needle of ponderosa pine that extends beyond the fascicle is fully grown. The cells of the needle divide and elongate at some point below the apex of the fascicle. This means that any additional lengthening of the visible part of the needle (that which extends beyond the fascicle) is brought about by cell division and elongation somewhere below the fascicle apex. Consequently, as an immature needle lengthens after it has been sprayed with an insecticide a fresh stretch of uncontaminated needle is produced from the fascicle outward. Since flathead adults feed mainly on that part of the needle at and just above the fascicle apex, tests with mature foliage sprayed when immature may give sharply differing results from tests with mature foliage sprayed when mature.

The pattern of cell division and elongation of ponderosa pine needles was determined by applying a series of dots of India ink at one mm. intervals along the exposed length of three, approximately one-half grown ponderosa pine needles. This linear series of dots, therefore, extended from adjacent to the fascicle apex to the tip of the pine needle. As these needles continued to grow, a stretch of needle without dots appeared just above the fascicle apex. The series of dots of India ink on the outer extremity of the needles were still one mm. apart. Therefore, cell division and elongation in ponderosa pine needles both take place at some point behind the apex of the fascicle sheath.

Flathead adults could not be obtained soon enough to test the influence of immature foliage on residual toxicity of DDT in diesel oil. By July 19 when beetles were available and when experiments were begun all the foliage of the test trees was fully developed. Therefore, the residual life of the insecticide was tested only on mature foliage.

Six, four-foot ponderosa pine were chosen as test trees. Two were sprayed with the equivalent of 2 lbs. of DDT per acre, two with 4 lbs. of DDT per acre and the remaining two were left unsprayed to serve as controls. When a tree was being sprayed care was taken to avoid contamination of other test trees. Most were separated by a great enough distance to negate this chance.

The six test trees were divided into two groups of three: each group containing a tree sprayed with the 2 lb. and one with the 4 lb. application and a tree that was unsprayed. The first group

was used to test the DDT foliar residue after it had aged one week (one week after application) and the second group was used to test the insecticide deposit at age five weeks.

The tests of residual action were made by caging the tree and introducing adult flatheads into the cages. Twenty-four hours after introduction and at each subsequent 24 hour period a tally was taken of the number that had died. The dead were removed at each mortality count.

MATERIALS

The insecticide formulation was as follows: 113.5 gm. of technical grade DDT (74 percent pp' isomer) dissolved in 250 ml. of an auxiliary solvent (Velsicol AR-50) and #2 diesel oil to total 500 ml. These proportions give a solution that is equivalent to 2 lbs. of DDT in 2 qts. of Velsicol AR-50 with #2 diesel oil to make one U.S. gallon of mixture. One gallon applied to one acre would give a 2-lb. deposit of DDT.

The insecticide was applied with a small, hand-operated sprayer having a pressure capacity of 200 lbs. The sprayer was pressurized with a tire pump and gave a deposit similar to what would be expected from an aerial application.

Drop cards were used as a visual aid in controlling the amount of insecticide applied. Short blasts of spray were ejected with the hand sprayer until the drop cards showed a deposit of 2 or 4 lbs. of DDT per acre as determined by standards given in the work of Yuill and Eaton 5/ for estimating drop size and quantity of spray deposited per acre. Two drop cards were placed on each test tree.

Cages were the same as used in previous tests of DDT as an aerial spray for controlling flatheads.3/ The cage was rectangular with 16-mesh, wire screening on the sides and top and muslin on the bottom. The only change in design was the installation of a hinged door at the base of the cage for introduction and removal of beetles. This design prevented loss of test subjects which was unavoidable with the previous design.

California flatheaded borer brood was obtained from ponderosa pine collected in the Miami Field Base area. Pine containing pre-pupal larvae were collected in the summer of 1955 and held at the

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5/ Yuill, J. S. and Eaton, C. B. 1951. "Airplane spraying for forest pest control." U.S. Dept. Agr. Pub. E-823, pp. 1-21.

Miami Field Base over the winter of 1955-56. Adults were reared for the tests in an outdoor insectary. Each adult was collected individually in a gelatin capsule for introduction into the test cages. Each cage received 50 beetles, all approximately 1-12 hrs. old, i.e. adults that had emerged from 1 to 12 hours before being exposed to the DDT deposits.

RESULTS

Table 1 shows the accumulative mortality obtained from a week-old deposit of DDT in diesel oil on ponderosa pine foliage. Table 2 gives the accumulative mortality for a five-week-old deposit. The data from both tables are plotted in figure 1. In the test of the five-week-old, 2 lb./acre deposit, observations of mortality were concluded after 13 days because of the similarity in mortality increments of cage no. 5, 2 lb. DDT/acre, and cage no. 6, control.

An examination of figure 1 shows both 2 lbs. and 4 lbs. of DDT/acre to be effective one week after application. All flatheads were dead from the 4 lb. dose after 4 days of exposure and from the 2 lb. dose after 5 days.

A five-week-old and a one-week-old deposit of DDT were shown to have similar toxicity when applied at the rate of 4 lbs./acre. The five-week deposit lagged somewhat behind the one-week deposit in speed of kill. The five-week-old deposit gave 100 percent mortality 6 days from the date of introduction of flatheads. It took 4 days from the date of introduction for all test subjects to die from exposure to the one-week-old deposit. The 2 lb./acre application showed a very marked decline in toxicity when aged for five weeks. It took 12 days of exposure to the five-week-old deposit to bring about 94 percent mortality. The daily increment of mortality in the control cage was approximately equal to that in the 2 lb., five-week-old test from about 9 days after introduction. Therefore, increments in mortality from the 2 lb., five-week-old deposit after 9 days of exposure can not be said to be due to the toxic action of the deposit. At 9 days, mortality from the five-week-old deposit was 86 percent.

DISCUSSION

Under conditions of confinement to small ponderosa pine, the California flatheaded borer adult can be killed by DDT-diesel oil deposits after these have aged several weeks. The quantity of insecticide deposited has much to do with the duration of resultant toxic effects.

Table 1.--Accumulative percent kill of flathead adults exposed to a week-old deposit

Cage	Dose DDT	Accumulative mortality by days				
		1	2	3	4	5
No.	Lbs./acre	Percent				
1	4	30	64	98	100	
2	2	2	54	86	96	100
3	0	4	4	8	10	10

Table 2.--Accumulative percent kill of flathead adults exposed to a five-week-old deposit

Cage	Dose DDT	Accumulative mortality by days												
		1	2	3	4	5	6	7	8	9	10	11	12	13
No.	Lbs./acre	Percent												
4	4	4	34	66	94	98	100							
5	2	8	22	30	48	68	76	78	82	86	88	92	94	94
6	0	0	0	10	18	24	32	38	44	44	46	48	50	50

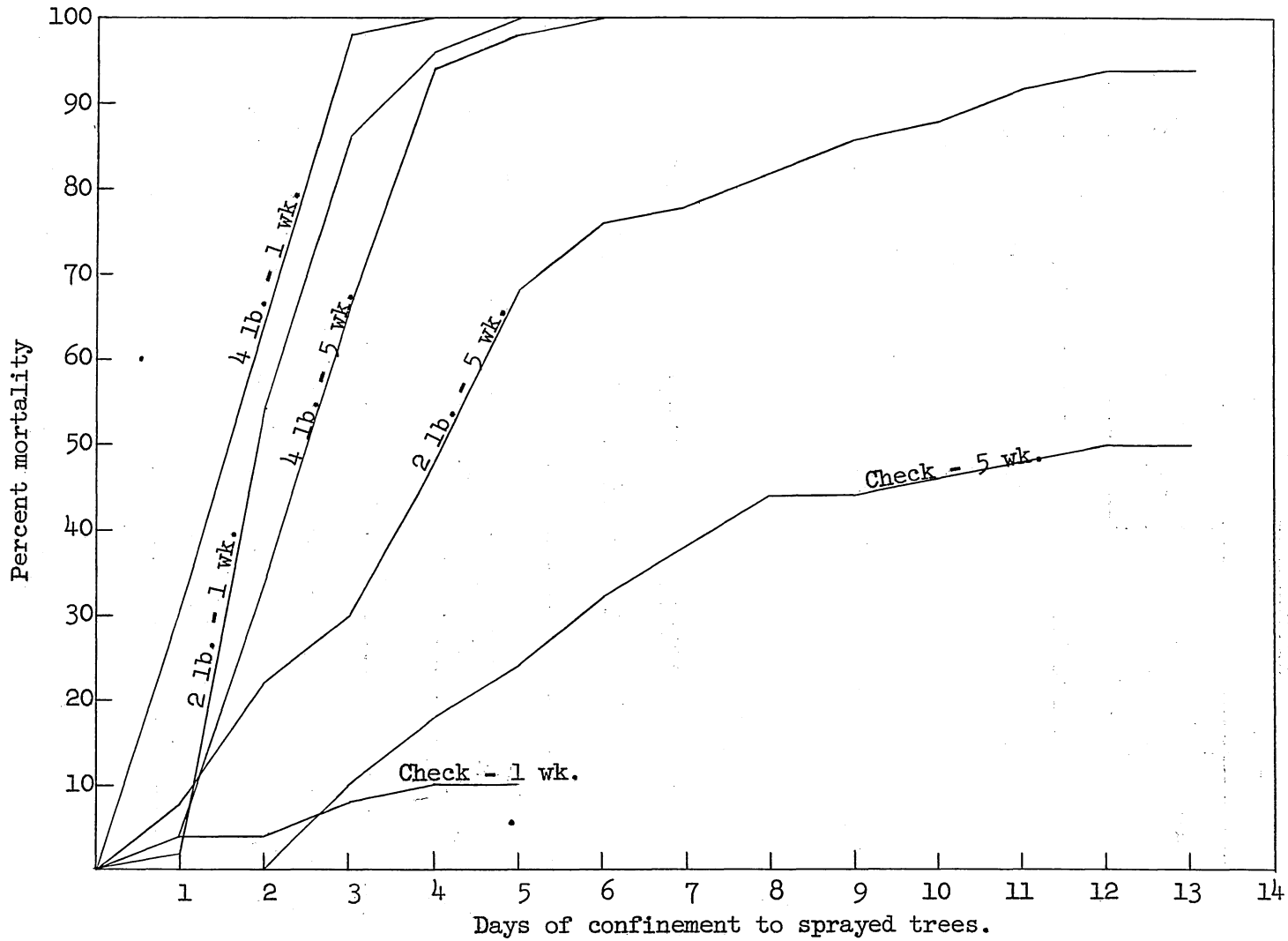

Figure 1.--Accumulative mortality of flathead adults exposed to one-week-old and five-week-old deposits of DDT in diesel oil on ponderosa pine foliage. Each curve is identified by dose and deposit age.

When the equivalent of 2 lbs. of DDT/acre was applied, toxicity as shown by bio-assay with adult flatheads was insufficient to kill 100 percent of the sample after the deposit had been allowed to age for five weeks. A deposit of this magnitude aged for one week was shown, on the other hand, to be able to kill the full 50 members of the sample population. In extrapolating, it seems that a 2 lb. DDT deposit will remain sufficiently toxic for control purposes up to two weeks or perhaps three weeks of age. With flathead emergence spread over a three-month period, a deposit toxic enough for control could be maintained on the foliage with an estimated minimum of four successive applications of 2 lbs. of DDT per acre applied at three-week intervals. This assumes that results in caged-tree experiments give a realistic picture of conditions in a field control program.

When the dose was doubled to 4 lbs. of DDT per acre, toxicity of a five-week-old deposit proved to be close to that of a one-week-old deposit. Both killed 100 percent of the sample population after about five days of confinement to the treated foliage. It is expected, therefore, that an application of this magnitude will remain adequately toxic for about 6 to 8 weeks. Assuming that adequate protection will last six weeks, a sufficiently toxic deposit might be maintained for a three-month period with two applications of 4 lbs. of DDT per acre; the first applied at the beginning of emergence and the second six weeks later. On the basis of these considerations, whether 2 lbs. or 4 lbs. of DDT/acre were applied at each spraying, a minimum of 8 lbs. of DDT would finally be applied to each acre. Consideration of the effects of immature foliage on lasting toxicity and thus on number of applications needed cannot be taken into account since the influence of such foliage has not been circumscribed. Immature foliage would exert its influence if any on the first one or two insecticide applications. The effect would be to reduce the toxicity of those applications made while the foliage was still immature.

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